the site conditions, DOE has a reasonable degree of confidence that protective conditions would be met and maintained both during the operation of the remedial action (75 to 80 years) and following achievement of water quality goals. Monitoring would confirm performance to meet target concentrations.

2.4 No Action Alternative

Although DOE would not remediate contaminated materials or ground water under this alternative, DOE would likely complete tasks necessary to secure the site to minimize the potential for accidents. For example, power would be turned off and equipment would be removed. This alternative is analyzed to provide a basis for comparison to the action alternatives and is required by NEPA regulations (40 CFR 1502.14[d]).

Under the No Action alternative, DOE would not remediate on-site surface contamination, which includes the existing tailings pile, contaminated materials and buildings, and unconsolidated soils. The existing tailings pile with its interim cover would not be capped and managed in accordance with 40 CFR 192 standards; this consequence of the No Action alternative would conflict with the requirements of the Floyd D. Spence Act. In addition, no site controls or activities to protect human health or the environment would be continued or implemented. Public access to the site would be unrestricted. All site activities, including operation and maintenance activities, would cease. Vicinity properties located close to the site and near the town of Moab, including residences, commercial and industrial properties, and vacant land, would also not be remediated.

Initial and interim ground water actions would not be continued or implemented. DOE would abandon all ongoing and planned activities designed to protect endangered species and prevent discharge of contaminated ground water to the Colorado River. No further media sampling or characterization of the site would take place.

A compliance strategy for contaminated ground water beneath the site would not be developed in accordance with standards in 40 CFR 192. Contaminated ground water would discharge indefinitely to the backwater areas of the Colorado River, and ammonia concentrations would continue to exceed protective levels. No institutional controls would be implemented to restrict the use of ground water, and no long-term surveillance and maintenance would take place. Because no activities would be budgeted or scheduled at the site, no further initial, interim, or remedial action costs would be incurred.

2.5 Alternatives Considered But Not Analyzed

This section addresses on-site and off-site alternatives, including locations, that were initially considered on the basis of preliminary assessment. However, they were eliminated from detailed evaluation for this draft EIS.

2.5.1 On-Site Alternatives

On-site alternatives for surface remediation that were initially considered included (1) stabilize-in-place, (2) solidification, (3) soil washing, and (4) vitrification. All but stabilize-in-place were eliminated from detailed evaluation. The rationale for elimination is discussed below.

Ground water compliance alternatives were evaluated in the SOWP (DOE 2003b), which evaluates the compliance strategies and serves as the basis for the strategy proposed in Section 2.3.

2.5.1.1 Solidification

This alternative involves adding a stabilizing reagent to a soil or sediment. The reagent fills the interstitial spaces, blocking the flow of water and other fluids into these spaces and reducing contact and leaching of contaminants. A study of polyethylene macroencapsulation conducted by DOE and Envirocare at the Envirocare site near Salt Lake City showed that this technology could be applied to reduce leachate from radioactively contaminated lead bricks.

However, a study of seven solidification/stabilization reagents for treatment of contaminated sediments at the New Bedford Harbor Superfund site in Massachusetts did not give encouraging results. Concentrations of RCRA Toxicity Characteristic Leachate Procedure metals, particularly barium, copper, and zinc, actually increased in leachate generated from a number of post-treatment samples (EPA 2001).

The current cost of the treatment system used at Envirocare (excluding the costs of the initial treatability studies that resulted in a viable technology) was estimated at \$90 to \$100 per cubic foot (ft^3) based on a demonstration performed on waste streams from 23 DOE sites (FRTR 2001). The estimated total volume of contaminated tailings and soils at the Moab site is approximately 8.9 million yd^3, or 240 million ft^3. Thus, the cost of remediating the Moab site using Envirocare macroencapsulation would be \$22 billion to \$24 billion. Macroencapsulation is inherently an ex situ process; therefore, this cost would be in addition to the cost of excavating the entire volume of contaminated tailings and soil. Because the solidified material would remain classified as RRM, it would still have to be disposed of as a radioactive waste. Additional disposal costs were not estimated because of the excessive costs associated with the treatment. Therefore, this alternative was eliminated from further assessment under this EIS.

2.5.1.2 Soil Washing

Notwithstanding the name, most soil-washing processes do not actually wash soils. Rather, they use water, sometimes combined with chemical additives, to separate contaminated soils into contaminated and clean constituents. Contaminants tend to bind to silt and clay. Soil-washing processes separate silt and clay from sand and gravel particles that constitute the bulk of most contaminated soils. The silts and clays, which contain the contaminants, must then be treated by other means before disposal. The sand and gravel can be disposed of as nonhazardous material. Soil washing, then, is a waste volume-reduction technology. It can be effective, resulting in volume reductions of as much as 90 percent.

Soil washing has been used at a number of Superfund sites, notably at the King of Prussia Technical Corporation site in 1993, where 19,200 tons of metal-contaminated soil and sludge were treated. The treated soil (sand and gravel) from the King of Prussia site met or exceeded all the treatment standards (EPA 1995).

Ashtabula, Ohio, is a DOE site where soil washing was used to treat 40,000 tons of soils commingled with depleted uranium. This application more nearly approximated true “soil washing” because it used a chemical extraction to leach the uranium from the soil. The results of this deployment appear to be mixed, although the volume reduction was nearly 98 percent (DOE 2001a).

Technical feasibility may be a serious obstacle to the use of soil washing at the Moab site. The uranium at the Moab site is chemically bound to the tailings because it occurs naturally in the ore, and the tailings are the by-product of the milling process. The uranium remaining in the tailings is that which remained bound to the substrate after the leaching process was used at the mill. It would likely be difficult to remove the uranium in a second stage of processing. Furthermore, a significant portion of the Moab tailings consists of slimes, which are difficult to handle in physical processes and do not disperse readily. The soil-washing systems used to date have relatively low capacities. The King of Prussia system operated at 25 tons per hour, so it would require 54 years to treat the Moab pile, assuming continuous operation. The Ashtabula system operated at 10 tons per hour, a rate that would require 136 years to treat the Moab pile. Pulse Technology, a private firm marketing a soil-washing technology developed with Russian aid, offers a stationary system that can process up to 90 tons per hour. This would treat the Moab pile in 15 years with no allowance for downtime. Because residual contamination would remain after soil washing, the resulting waste would still have to be managed and disposed of as radioactive waste.

Soil washing is an expensive technology. The project cost at the King of Prussia site was $7.7 million, or $401 per ton of soil (EPA 1995). The unit treatment cost at Ashtabula was estimated at $370 per ton (DOE 2001a). Either of these figures, if extrapolated to the total volume of more than 11 million tons of contaminated tailings and soils at the Moab site, results in a total treatment cost of more than $4 billion. The lowest cost suggested by EPA for soil washing is $90 per ton (DOE 2001a), equivalent to $1 billion for the Moab site. To make soil washing economically feasible at the site, the unit costs would have to be an order of magnitude lower than those reported at the other sites where that technology has been used. There is no indication that such a reduction could be achieved.

2.5.1.3 Vitrification

This treatment alternative uses electricity to heat contaminated soils to their melting points in place, then allows the melted soils to cool as glass. The high temperatures required for vitrification (quartz melts at 1,610 °C [2,930 °F]) destroys many contaminants, and contaminants that are not destroyed are encapsulated in the glass.

Vitrification has been used at a number of DOE and other sites to treat small quantities of high-level radioactive waste. It is particularly useful for treatment of high-level liquid wastes. The Savannah River (Pickett et al. 2000) and Hanford Sites (62 FR 8693–8704 [1997]) are using vitrification for this purpose. An in situ vitrification (ISV) treatment system was successfully used to treat contaminated soils and sediment at the Parsons Chemical/ETM Enterprises Superfund site (EPA 1997). Oak Ridge National Laboratory (ORNL) has successfully demonstrated a transportable vitrification system for ex situ treatment of contaminated soils (DOE 1998). An in situ pilot test at Brookhaven National Laboratory in 1996 was less successful and, as stated in the report on that test, "raised concerns about the effectiveness of ISV" (DOE 1996b).

The quantities of wastes treated by vitrification have been small compared with the volume of contaminated tailings and soils at the Moab site. The ORNL ex situ demonstration (DOE 1998) treated about 8 tons of mixed waste, and the Parsons Chemical/ETM project (EPA 1997) treated approximately 3,000 yd^3 of soils and sediment. The estimated volume of solid material at the Moab site is 8.9 million yd^3.

Partly because of the relatively small volumes treated, the reported unit costs of ISV projects have been high.

- The ISV project at the Parsons Chemical/ETM Enterprises Superfund site in Grand Ledge, Michigan, which treated approximately 3,000 yd^3 of contaminated soils and sediments in 1993 and 1994, reported a cost of $270 per cubic meter (equivalent to $353 per cubic yard).
- DOE's report on ISV reported average costs of $375 to $425 per ton for projects at Parsons, ORNL, Wasatch, and a private Superfund site.
- "High Temperature Plasma Vitrification of Geomaterials" (Mayne and Beaver 1996) reported a range of operating costs of $308 to $695 per cubic meter (equivalent to $403 to $909 per cubic yard).

The total treatment cost of the ORNL ex situ transportable vitrification system was calculated at $8 to $15 per kilogram ($18 to $33 per pound).

Applying the average of the costs of the in situ processes (excluding the ORNL ex situ transportable vitrification system) to the total volume of the tailings and contaminated soils at the Moab site yields an estimated total cost of more than $4 billion for remediation of the site using ISV. Some economy of scale would be realized in a project the size of Moab. However, the most significant cost element in a vitrification process is electricity. DOE used an estimated unit cost of $0.05 per kilowatt hour to derive the cost range for vitrification projects, and it is highly unlikely that the cost of electricity for the Moab project would be significantly lower than this value. To make vitrification economically feasible at Moab, the unit costs would have to be more than an order of magnitude lower than those reported at the other sites where that technology has been used. The consistency between the reported unit costs for the various ISV projects suggests that an order of magnitude reduction is unlikely. In addition, as with other treatment alternatives, this waste would still need to be managed and disposed of as a radioactive waste.

2.5.1.4 On-Site Relocation

Moving the pile to another location on the Moab site was considered but dismissed as an alternative. DOE is already analyzing an on-site disposal alternative and there do not appear to be any advantages offered by relocating the tailings elsewhere on the site. Any alternate locations on the Moab site would result in more of the tailings pile/disposal cell lying in the 100-year floodplain of either the Colorado River or Moab Wash, thereby increasing the risk of flooding and decreasing cell integrity. One of the major objections to the existing pile is its proximity to the residents of Moab, to the Colorado River, and to Arches National Park. Moving the cell to a different location on the Moab site would not remedy these concerns and is likely to result in the relocated cell being closer to one of these three receptors. Although a relocated on-site disposal cell could be designed with a liner, it would continue to be located directly over an aquifer that feeds the Colorado River. Potential liner failure would pose a threat of contamination of the ground water and thus the Colorado River.

2.5.1.5 Removal of Top of the Pile

Because ammonia is the primary contaminant of concern and because it appears to be concentrated in the top of the pile due to the presence of a salt layer, some commenters have suggested that an alternative disposal strategy might be to remove the top portion of the pile (for example, the top 10 ft) for off-site disposal and cap the rest of the pile in place. However, DOE does not believe such a strategy offers potential advantages sufficient to warrant full analysis. While acknowledging that a salt layer may exist in the upper part of the pile and that leaching of ammonia from this layer could result in a temporary resumption of non-protective surface water quality, modeling suggests that the potential impacts to surface water and aquatic species from salt layer leaching would not occur for at least 1,000 years. Moreover, partial removal of the pile would be the worst alternative in terms of proliferation of sites requiring long-term monitoring and stewardship. To some degree, removal and transportation of just the top of the pile would entail all of the unavoidable adverse impacts associated with full off-site disposal but would not result in any of the benefits to be accrued at the Moab site through full off-site disposal. DOE does not believe the alternative offers any compelling benefits in terms of impact or cost.

2.5.2 Off-Site Alternatives

2.5.2.1 Off-Site Surface Locations

Several off-site locations were considered for surface disposal of contaminated materials. All sites are within the state of Utah and included the following:

- Envirocare
- ECDC
- Green River
- Box Canyon
- Rio Algom
- Cisco site
- Whipsaw Flats
- Summo Minerals Lisbon Valley

These alternate locations for surface disposal were eliminated from further consideration on the basis of the following factors:

The licensed capacity of the Envirocare site is only half of the volume of tailings at the Moab site that would require disposal. Additional capacity for the tailings would require an amendment to the existing license from NRC and an environmental evaluation. The tailings-transport distance to the Envirocare site would be over 200 miles (170 miles farther than the Crescent Junction site). Transportation costs associated with disposal of the tailings at Envirocare would be prohibitive.

ECDC formally withdrew its site from consideration shortly after the Notice of Intent To Prepare an EIS was published. At the Green River site, the location of the Green River floodplain in the northern portion of the site would limit placement of a disposal cell to the area south of the Probable Maximum Flood (PMF [see definition in Chapter 1.0]) boundary. The site is also bounded by I-70, which would severely restrict the space available for cell construction and disposal. The Box Canyon site would be limited by several small washes formed by surface runoff at the site, and the space is limited for a tailings pile. In addition, the Box Canyon site is located in an area frequented by tourists and outdoor recreationists, making it incompatible with a tailings disposal facility.

The Rio Algom facility was not considered a viable disposal site because (1) shallow, contaminated ground water exists in the Burro Canyon aquifer, (2) the ACL application has already been submitted to NRC for approval and termination of the license, contingent on existing conditions, and (3) adjacent property has already been acquired to provide an institutional control over the site-related contamination in ground water, and it may be impractical to expand farther.

The Cisco site is located 30 miles farther from Moab than the Crescent Junction site, and transportation costs would be higher compared to those for the Klondike Flats or Crescent Junction sites. Also, the Cisco site does not offer disposal criteria that are better than those at the Klondike Flats site. The Whipsaw Flats site is close to Arches National Park, and NPS personnel have opposed this location because the disposal site would be visible from portions of Arches National Park. In addition, this site would not offer any advantages over the Klondike Flats or Crescent Junction sites and would be more difficult to access than either the Klondike Flats or Crescent Junction sites.

The Summo Minerals Lisbon Valley site was proposed by a private copper mining company who suggested that the Moab tailings could be co-deposited with copper ore heap-leach residues. The Lisbon Valley site is located roughly the same distance from Moab as the Klondike Flats site, but the hydrogeology is less favorable.

Comments received in scoping meetings suggested several other off-site alternatives or related actions. These were considered but dismissed as described in the following discussions.

Railroad to White Mesa Mill Site—DOE considered but dismissed construction of a new railroad line from the Moab site to White Mesa Mill as an alternative because of the potential for extensive environmental impacts, technical difficulty, and cost. Minimum construction costs for a new rail line are typically in the range of $1 million to $3 million per mile, depending on terrain. In areas where the grade exceeds 1 to 2 percent, the line would have to be routed to avoid these grades, thereby adding to the total mileage, or the railbed would have to be graded to 1 to 2 percent, which would add to the cost and terrestrial impacts. A railroad bridge crossing the Colorado River would be a major additional expense and would require extensive and unforeseeably complex and lengthy permitting issues and potential delays in completing the construction. Acquisition or leasing of undisturbed land, much of it privately held, would be an additional expense, as would the necessary land surveys and road crossings, and there would be no guarantees that the required land could be secured without condemnation proceedings. DOE estimates that capital construction costs of a new 90- to 100-mile railroad from the Moab site to the White Mesa Mill site would exceed $150 million, including land surveys/acquisition and track, bridge, and road crossings construction. This is almost twice the projected capital construction costs for building a pipeline. Based on these higher capital construction costs, uncertainties surrounding the permitting process, and the likelihood of significant environmental impacts, this alternative was dismissed from further consideration.

Old Mines—Disposing of the contaminated tailings in old mines was dismissed from consideration because (1) no single mine in the region had sufficient volume to contain the contaminated material from the Moab site, (2), mines are typically excavated by blasting, and consequently can be structurally and geologically unstable, and (3) old mine shafts could also be susceptible to explosions, poisonous gas, and cave-ins. The use of mines under these conditions would pose serious logistical and worker occupational safety and health concerns.

Grand County Landfill—Using the Grand County landfill or allowing Grand County to own or direct operations of the cleanup area was dismissed because the landfill is neither permitted for nor technically designed for radioactive waste.

River Rerouting—Rerouting the Colorado River away from the Moab site was dismissed as an alternative because of the broad range of adverse and irreversible environmental impacts to the Matheson Wetlands Preserve that such an undertaking would entail.

Land Use—Converting the site into a golf course was suggested but is not considered an alternative remediation action. Rather, it is a potential future land use suggestion that will be considered at a later time.

Use of Contaminated Water—Contaminated ground water could possibly be used to augment the slurry pipeline recycle makeup water requirements or, depending on schedule, to augment the nonpotable requirements for the initial pipeline slurry. However, the anticipated 150 gpm of pumped contaminated ground water would be less than 40 percent of the required 409 gpm of makeup water (see Table 2–12). If the pipeline option were implemented, the effluent discharge options discussed in Section 2.3.3 would be evaluated, and a preferred option or combination of options would be selected for more detailed technical and engineering review. Use of contaminated water to augment the slurry water requirements would be evaluated at that time.

2.5.2.2 Disposal in Mined Salt Caverns

In late 2003, DOE considered an option to dispose of the Moab mill tailings in solution-mined salt caverns either at the Moab site or off site at two potential locations. Conceptually, disposal caverns would be created by solution mining in the salt beds of the Paradox Formation beneath the Moab site or at other possible locations, such as the commercial potash mine site approximately 6 air miles downstream from Moab. This option would involve withdrawing Colorado River water for the solution mining process; the water would become saturated with salt, generating brine that would have to be disposed of by deep well injection or solar evaporation or perhaps by use in the potash mining operations. Appendix E presents DOE's evaluation of this alternative approach.

Disposal in mined salt caverns is an unproven approach to uranium mill tailings disposal that would require immense amounts of Colorado River water (approximately 1,700 gpm of freshwater, roughly 880 million gallons per year or 73 million gallons per month) for a 20-year period to perform solution mining activities. DOE does not currently own the rights to withdraw this much water and, if they could be purchased, DOE would be required to pay water depletion fees associated with compensation of existing water right holders because of impairment.

DOE's programmatic experience with the complexity of implementing a first-of-a-kind unproven disposal technique for radioactive waste indicates that implementation of this option could be 3 or 4 times as long as all other alternatives (up to a few decades to go operational, a 20-year operations time frame, and a project life cycle range of multiple decades). Technical, geological, hydrological, seismological, legal, economic, and operational uncertainties present a real potential for substantial schedule and cost growth over current estimates. More specifically, these technical and operational uncertainties include (1) the location of favorable geologic strata that could be used for disposal of the brine by deep well injection and the rate and extent that brine could be injected; (2) the location, depth, and configuration of the caverns to be solution mined in the Paradox Formation; (3) the long-term performance of salt caverns in isolating the mill tailings; (4) the private/government business model that could allow use of the salt or brine, (5) the consumption of significant quantities of Colorado River water, which may be more than is available under DOE's water rights, and possibly more than what would be acceptable under the recovery program for endangered fish; (6) the high potential cost (approximately $892 million to $1.3 billion); and (7) high potential for cost growth well beyond the range identified for other alternatives.

Resolving these uncertainties sufficiently to determine whether this alternative would be technically feasible and cost-effective would require a significant investment in additional studies. Such studies would include injection well testing, subsurface characterization, salt cavern performance modeling, an assessment of legalities, and an overall system performance assessment. The studies could require several to tens of millions of dollars and many years to complete, with no guarantee that the investment would demonstrate that this alternative is technically viable or offers substantive advantages to DOE or the public relative to the other alternatives being considered. Because the available data are not sufficient to provide the basis for a decision of this magnitude, DOE would need to delay the EIS to obtain this information.

An advantage of the solution-mixed salt cavern approach is the potential for longer-term isolation and more protection than that offered by other alternatives. Other advantages are that (1) salt cavern disposal would produce the least long-term environmental impact because no surface footprint would remain at the conclusion of the disposal period, and (2) this approach provides another disposal option for contaminated ground water for 50 of the 75 to 80 years required for active ground water remediation.

However, on the basis of the evaluation of this option and review by the 12 cooperating agencies and given the technical, legal, and economic uncertainties associated with this unproven technical approach, DOE's past experience, and the potential advantages with respect to the existing alternatives and the disadvantages, DOE has concluded that this option is not "practical or feasible" and has therefore decided not to include salt cavern disposal as a reasonable alternative in the EIS.

2.6 Description and Comparison of Environmental Consequences

The following text summarizes the potential impacts (both adverse and beneficial) to the physical, biological, socioeconomic, cultural, and infrastructure environment that could occur under the on-site disposal alternative, the off-site disposal alternative, and the No Action alternative. Human health impacts are also summarized. This section also compares the major differences in impacts among the alternatives and the differences among transportation modes under the off-site disposal alternative. It is based on the consequences, including assumptions and uncertainties, identified in detail in Chapter 4.0 of the EIS.

2.6.1 Impacts Affecting the Moab Site and Vicinity Properties, Transportation Corridors, and Off-Site Disposal Locations

Geology and Soils. Under either the on-site disposal alternative or the No Action alternative, the combination of the processes of subsidence and incision would slowly affect the tailings pile by lowering it in relation to the Colorado River. This impact would not occur under the off-site